

# Remarkable Relation from Minimal Imaginary Action Model \*

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## Abstract

If it is to be true that the history of the universe should minimize the “imaginary part of action” [1] [2] it would be “easiest” to have this “imaginary part of the action” to be rather independent of whether the neutrons are converted to electrons and protons (and neutrinos), and therefore of whether the contribution to the imaginary part of the Lagrangian were conserved under this conversion. Under the further assumption - which is reasonable - that the by far dominant term in the imaginary part of the Lagrangian density is the one corresponding to the Higgs mass square term in the Standard Model Lagrangian density  $m_H^2 |\phi(x)|^2$  we derive a relation

$$\sqrt{m_d^2 - m_u^2} = \sqrt{m_{\text{constituent}} * m_e} / \sqrt{“ln”} \quad (1)$$

where “ln” is defined by  $\langle \gamma^{-1} \rangle = “ln” / \langle \gamma \rangle$  and is of the order of 1 to 4, where  $\gamma$  stands for relativity  $\gamma$  of a valence quark inside a nucleon. This relation is very well satisfied with the phenomenologically estimated current algebra quark masses  $m_u$ ,  $m_d$ , and the constituent mass  $m_{\text{constituent}}$  for the light quarks, taken say to be one third of the nucleon mass.

Our model has been criticised on the ground that it should have prevented cosmic rays with energies capable of producing Higgs particles, when hitting say the atmosphere. Indeed there is, however, a well known “knee” in the density curve as function of energy at an order of magnitude for the cosmic ray particle energy close to the effective threshold for Higgs production.

A parameter giving the order of magnitude of number of Higgses to be produced in order to get a significant effect is estimated to be about  $3 * 10^5$ .

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# 1 Introduction

Recently Ninomiya and I [1][2] have put forward after some thinking on time machines [3] a model in which the action - of the Standard Model say - gets provided with an imaginary part. This having a model for the *initial conditions* is also a subject already touched upon by me and Bennett much earlier [5][4]. It were suggested that the term in the Lagrangian density corresponding Higgs mass square  $m_H^2 |\phi(x)|^2$  should dominate the imaginary part and that leads to the main effect of the model being to predict that accelerators producing large amounts of Higgs particles should be likely to have bad luck in the sense of not coming to fully work.

It is a major point of the present article to point out that with the actually natural assumption of the Higgs mass square term dominating the number of parameters in the imaginary part of the action is formally reduced to the imaginary part  $m_H^2|_I = Im(m_h^2)$  of the mass square term coefficient. In reality the exact variation of the integrated square of the Higgs field might be not completely easy to evaluate and a few parameters parametrizing the difficulties in performing calculations which in principle can be done might have to be included into the model.

We have in earlier works already argued, that for a situation with only massless and conserved non-relativistically moving particles the effects of the situation on the imaginary action  $S_I(history)$  become trivial and thus there will be in this approximation no effect of the requirement predicted by our model for governing the initial conditions of the universe so as to arrange that what really happens minimizes this imaginary part of the action  $S_I(history)$ .

We should thus only make unusual predictions when either

- a) Some particles are not either massless or non-relativistic, (In that case namely a more complicated form for the eigentime for such particles would appear, than for massless or non-relativistic particles with the eigentimes being respectively zero and equal to the usual coordinate time; more complicated eigentime would mean also more complicated action, say the imaginary part, because the action goes as the eigentime.) or
- b) Some particles are not conserved, but say converted into each other or simply appear or disappear. (Such decay or appearance would of course make the to the action connected eigentime depend on when the appearance and decay occurs so that the history would influence the (imaginary) action under such conditions)

The point of the trivial contributions to the “imaginary part of the action” when the two mentioned deviations from daily life physics are avoided is easily understood by noting that the action - it being the real of the imaginary part - of a propagating particle, say from one interaction to the next, is a constant times the (relativistic)eigentime:

We namely then immediately see that at least between the interactions - and interactions will in daily life physics take up a relatively short time compared to the free times - the massless particles contribute zero because their eigentimes are zero, and the non-relativistically conserved particles contribute just proportional to the frame time in the frame in which they are non-relativistic, provided of course that they are conserved so that they are indeed present at all times.

In the so to speak daily life approximation we only meet protons, neutrons, electrons and massless particles meaning mainly the photon. Among these particles only the nucleons attain velocities approaching relativistic speeds inside the nuclei, which themselves are only seldomly converted into each other. As long as the nuclear reactions do not occur and the motions of the particles remain non-relativistic the imaginary action contributions remain trivial to good approximation and severe governing of the universe effect such as some apparatuses having “bad or good luck” should not occur.

Astronomically there does, however, occur some transformations of electrons plus protons into neutrons and neutrinos. Since the neutrinos are to first approximation massless they should not contribute to the imaginary part of the Lagrangian for that reason. But a priori, unless the contributions to the imaginary part of the Lagrangian of a neutron were almost miraculously tuned in to be the same as that from the electron and the proton together there would be a significant change in the imaginary part of the lagrangian  $L_i$  each time the reaction

$$e + p \leftrightarrow n + \nu_e \tag{2}$$

runs one way or the other.

It is the main point of the present article to argue for that it could be likely that the minimization of  $S_I$  would lead to a tune in of parameters that would organize this transition  $e + p \leftrightarrow n + \nu_e$  to *not* change the  $L_I$ . The idea is in the direction that other features of the initial conditions can be adjusted more freely without having to take care of their influence on the amount of transitions of this type of “neutron decay” taking place or at what time they take place.

For the argument for this sort of finetuning being likely to occur we refer to section 3.

## 2 Review of our Imaginary part of Action Model

One may formulate the model by M. Ninomiya and myself [1] by saying that we use a certain way of interpreting the Feynman-Dirac-Wentzel path way integral (a bit different from the usual use) we assume that the action  $S[path]$  has also *an imaginary part*. This means of course that we write the action  $S$  to put into the Feynman path way integral

$$\int \exp(\frac{i}{\hbar} * S[path]) \mathcal{D}path \quad (3)$$

as

$$S[path] = S_R[path] + iS_I[path] \quad (4)$$

where of course  $S_I[path]$  is the imaginary part, which is zero in the usual theory, but assumed to be a functional of quite similar, but not identical, form to that of the real part  $S_R[path]$ .

It is immediately obvious that, while in the usual theory in which there is no imaginary part of the action, i.e.  $S_I[path] = 0$ , the integrand of the path way integral  $\exp(\frac{i}{\hbar} * S[path])$  is a complex number with unit numerical value, the inclusion of our imaginary part makes the integrand able to take a pathdependent numerical value. In fact it is seen that assuming the imaginary part to be a priori of a similar order of magnitude as the real part of the action and remembering that compared to daily life, when classical approximation is often good enough, the Planck constant  $\hbar$  is in principle small the suppression of the integrand for positive  $S_I[path]$  and the enhancement for negative  $S_I[path]$  are enormous. Without further details this clearly points towards the idea that the paths which do not have their  $S_I[path]$  being minimal inside the range of paths not brought to be made irrelevant for other reasons must come to dominate the path way integral.

Now it is wellknown that one can in the usual path way integral formulation argue for the classical equations of motion to appear as a saddle point approximation in the evaluation of the Wentzel-Feynman-Dirac path way integral. Basically the idea in the derivation from the path way integral of the classical equations of motion comes from that unless we sum up the different path contributions in the neighborhood of a path for which the variation of the action is zero

$$\delta S[path] = 0 \quad (5)$$

the phase of the integrand will vary over the neighboring region of that path so fast, that essentially the contributions cancel out, and we get very little resulting contribution from the neighborhood of such a path.

Very crudely we might take this phase variation argument to mean that only the neighborhood of paths for which

$$\delta S_R[path] = 0 \quad (6)$$

will survive (i.e stay making a significant contribution to the path way integral) and that then the *path which among these classical solutions* have the minimal value for  $S_I[path]$  will dominate. This approximation strictly speaking does not work when the  $S_I$  gets big, but we believe to have arguments that it will work approximately in practice.

## 2.1 We include the future

A most important point in our way of applying the path way integral compared to what is usually done is that we *include the contributions from the future* into the integral form of the action

$$S[path] = \int_{-\infty}^{\infty} L(path(t), \frac{dpath(t)}{dt}) dt. \quad (7)$$

This inclusion of the future has the very important consequence that the question as to which path inside, say the class of those ones obeying the classical equations of motion, gets the minimal value of the imaginary part of the action  $S_I[path]$  and thus should be the most important path depends not only on what goes on along this path in the past, but also *in the future*. That has the consequence that it will look in our model as if the initial conditions have been *selected with some purposes of arranging in the future some happenings that could make especially numerically big but negative contributions to  $S_I[path]$* . Such prearrangements to obtain especially negative contributions to  $S_I$  even from the future will be conceived of as *miraculous coincidences seemingly made with a purpose*. Provided our speculation that especially the production of Higgs bosons in large numbers should cause exceptionally large positive contributions to the imaginary part of the action  $S_I$  we expect the typical miraculous coincidences of this type to be the coincidences of small bad lucks leading to that a great accelerator meant to produce a lot of Higgs bosons after all gets in trouble and does not at the end come to work. We have since long proposed that the case of the stopping in 1993 of the budgets for the SSC (= Superconducting Supercollider in Texas) by the U.S. Congress were a case of such a prearranged set of coincidences “made up” to stop the potential great amount of Higgs bosons being produced.

## 2.2 The classical approximation law of initial conditions

As we have just stated the bunch of paths that will dominate the Feynman-Wentzel-Dirac path integral in our model with its complex action is expected to be

- 1) a bunch around a classical solution (since otherwise the phase from the integrand corresponding to the different paths in the bunch would vary so as to make the contribution of the bunch wash out)
- 2) the bunch of this type having the minimal - in the sense of being most negative - imaginary part of the action  $S_I(history)$ .

Supposing that the point 1) can be apprimated by just including the real part of the action and taking the usual classical equation of motion written in the usual extremizing the action way,

$$\delta S_R = 0, \quad (8)$$

the point 2) takes formally the form of a minimization among all the classical solutions

$$LAW\ OF\ INITIAL\ CONDITIONS : \quad (9)$$

$$S_I(history)\ MINIMAL. \quad (10)$$

This is much like a law of “the will of “God” ”.

## 2.3 Suppression of the effect of the imaginary part $S_I$

Both for the performance of the argument for the main effect indeed being of the form that the classical solution selected to be realized is the one with the minimal imaginary part of the action  $S_I$  and for obtaining agreement with the phenomenological fact that after all we see extremely few - if at all any - prearranged events we need for our model to be viable that in some way effectively the imaginary is small. By prearranged event we here meant that we should see something requiring an explanation involving special finetuning of initial conditions so as to arrange some special thing to happen later. Even if we would count the failure of the SSC machine as such a case and include some miracles from the bible etc. such events - which might be called cases of backward causation - are extremely rare.

So we have in our model the problem that we either have to assume that even if there is an imaginary part of the action then it is very small, or we have to present a mechanism, that even if there is a priori say an imaginary part of the action being of the same order as the real one, then in practice we shall see effects only as if it were much smaller.

### 2.3.1 An important argument for suppressing the effect of the imaginary part of the action

The argument for suppressing the effect to which we have most hope is of the type that each period of time, each era, cannot have very much say about the initial conditions, because there is only one set of initial conditions to determine what happens in all the many eras through the history of the Universe:

One may see each era in the development of the Universe as having different developments, all being though described according to the equations of motion being integrated up from the same initial conditions. It is the same equation of motion solution that must describe what goes on in all eras from the earliest times to the latest times. Since the solutions are so to speak in one to one correspondence with the state (in phase space) at one moment of time there are of course not freedom enough to adjust for the optimal (meaning  $S_I$  being minimal) happening for all the many eras with the same solution. Rather the minimization of the imaginary part of the action  $S_I(history)$ , which is an integral over all times, must be determined as a compromise between “wishes” from the many different eras. But that will then in each separate era make events happen that do not precisely make the  $S_I$ -contribution from just that era become minimal. Rather it would look from the point of view of one single era as if what happens is mainly determined from the influence on the choice of solution from quite different eras. Really to make our model match with phenomenological facts we must hope that for some reason in our model the era of the big bang time contributes especially strongly to  $S_I$  so that what we observe will in first approximation look like being determined by organization of an arrangement of what went on in the Big Bang time(s). Thereby it will namely come to look as if the past is fixed so as to fulfill some - especially negative  $L_I$  - story during that era, and then we mainly just “see” the essentially unavoidable development of this in a big bang era fixed solution to the equations of motion.

## 3 The need for $L_I$ being insensitive to Neutron decay or its inverse

A priori our model predicts that the minimization of the imaginary part  $S_I(history)$  occurs by selecting the *history* by selecting the initial conditions mainly. Contrary to that we at first should think of the coupling constants and parameters such as masses as being fixed by nature in a different way, a priori. However, there are ways in some models such as baby-universe theory that initial condition given quantities could achieve to influence the world effectively as if the parameters as coupling constants etc. were dependent on the initial conditions and thus in our model also should be adjusted - at least to some extent - to minimize  $S_I$ , to some extent as if this  $S_I$  also depended on some parameters parametrizing the coupling constants and mass-parameters.

In arguing for how the parameters, such as coupling constants masses etc., might be adjusted to the degree that they are accessible to being changed in the procedure of minimizing “the imaginary part of the action”  $S_I[history]$  we could imagine a picture, that the vacuum has a very complicated structure with many fields, that could be adjusted from the start and then would stand so further on. Then namely the adjustment of the initial situation w.r.t. these “parameters of the vacuum” could cause an effective way of getting the minimization of  $S_I$  also determine - still may be within some restrictions though - the coupling constants and mass parameters etc.

Think of there being a set of parameters that are accessible to being tuned on to vary  $S_I$  and then we know the realized choice should be one with  $S_I$  having been minimized. Out of the choice of the set of parameters we think of there might result the number, say, of the collected existence time for all the neutrons  $T_{neutrons} = \sum_i t_i$ , meaning the sum of the time of existence  $t_i$  of all the neutrons, indexed by  $i$  in the world exist (free or inside the nuclei in which there stability has been increased). We might even think of this collected lifetime of all the neutrons  $T_{neutrons}$  as one of the adjustable parameters, if we wish to do so. But if we think this way, then assuming a smooth behavior of the  $S_I$  to be minimized as function of the parameters we should deduce that the *derivative* of  $S_I$  w.r.t. the collected neutron life

time  $T_{neutrons}$  should be *zero*. This is just the usual rule of the derivative being zero at a minimum. Now most of the contribution to the collective neutron existence time comes presumably from the era which is dominated by the physics of “dayly life” as we called it above. Now when we think of varying the collected neutron existence time it will of course occur by shifting the transformation of the neutrons to proton plus electron under absorbsion of the neutrino or opposite earlier or later in the history *history*. The effect of such a change in the history - by changing some parameters - will change the total  $S_I(history)$  for two sorts of reasons:

- 1 There will simply be the change due to the difference in the  $L_I$  coming from proton + electron versus that from neutron + electronneutrino.
- 2 There will be all the other changes caused by the shift in the variables that were to be changed in order to arrange for the change in the neutron collective existence time  $T_{neutrons}$  we wanted to change. A priori this change could be big, because changing the parameters will typically change e.g. the imaginary part of the vacuum Lagrangian density  $\mathcal{L}_I$ , and since there is a huge amount of vacuum this could be very big amounts of  $S_I$ -contribution. However, now we want to argue that we have the freedom when discussing how to produce a given little change in the collected neutron existence time  $T_{neutrons}$  to choose which parameter to use. If there are many possible parameters to vary - or for some reason there are great chance that the choice of parameter can lead to very small effect on  $S_I$  if the parameter is chosen appropriately -, then we could choose likely the parameter to play with to cause only small influence on  $S_I$  via other effects than just via the collected neutron existence time.

If we indeed take the choice among many parameters to vary when thinking of varying the collected neutron existence time to minimize the variation of  $S_I$  described under point 2, then we may argue that the variation under point 1 will dominate. The latter is, however, *calculable* in principle, since we have assumed the  $L_I$  to be dominated by the term in the imaginary part of the Lagrangian density, which is proportional to the Higgs field square - we argued in fact for the imaginary coefficient part of the Higgs mass term to dominate-. But this then means the variation due to the change - as under item 1 - in the collected neutron existence by itself shall be zero. Now this change in  $S_I$  is proportional to the difference in  $L_I$  for a resting (or just non-relativistic) proton plus a resting electron relative to that of a resting neutron. The neutrino is massless and we ignore its  $L_I$ -contribution. Therefore the argumentation from the minimization of  $S_I$  leads to that this difference must have been adjusted - somehow or another - to be zero.

This is the basis for the relation which is the main result of the present article, i.e. our prediction comes from the imaginary action being minimized w.r.t. the collected neutron life time  $T_{neutrons}$  and thus having zero derivative.

Even if the above argument for the zero derivative of  $S_I$  w.r.t.  $T_{neutrons}$  and thus the change in  $L_I$  under neutron decay being zero were not convincing from a completely theoretical point of view, we can at least note phenomenologically, that there is in nature today both neutrons and neutron-decay products, protons and electrons (and (anti)neutrinoes) in comparable amounts. If indeed there were a difference in the imaginary part of the Lagrangian  $L_I$  for the neutron and its decay products then it should in our model go so that either all the neutrons disappeared or all the protons and electrons were made into neutrons. Neither of these two predicted possibilities seem to have been even approximately realized in nature. Thus our model will be in trouble unless the change in  $L_I$  under neutron decay is indeed zero. With the enormous amounts of neutrons in the world one would get an enormous effect of selection of the history with an exponentially easily enormous factor.

## 4 The interesting relation

Now we shall evaluate the difference between the  $L_I$ -contribution of the two pairs of particles on the sides of the equation (2) because that is what we predict to be zero.

Now we have that the main interaction with the Higgs field of some particle such as a quark or an electron simply comes via the Yukawa coupling which in turn is proportional to the mass of the particle in question. Since we have hypotesised, that it is the square of the Higgs field, which gives us the  $L_I$

dominant term, and we expect for small interactions that this square will vary proportional to the Yukawa coupling, we expect that the contribution from the passage, of a quark say, by multiplying the eigentime for the periode considered with the mass of the quark

Since a similar relation holds for the electron, say, we can thus see that for a non-relativistic electron the contribution to  $L_I$  is simply proportional to the electron mass  $m_e$ . With same proportionality the contribution to the  $L_I$  from a non-relativistic proton say will of course get three contributions one from each of the three quarks, but now these quarks are not non-relativistic but rather move most of the time pretty relativistically. Rather we have that the amount of eigentime spent per unit time in the rest frame of the proton is proportional  $\gamma^{-1}$ , where  $\gamma$  is the relativistic  $\gamma$ -factor for the quark (in the proton system). Of course this eigentime correction factor  $\gamma^{-1}$  fluctuates quantum mechanically and in reality has a distrubtuion rather than a special value. Nevertheless we expect that very crudely it behaves similarly to the inverse of the average of the  $\gamma$ -factor itself, and we have found it suitable to define a factor of order unity " $ln$ " by the relation

$$\langle \gamma^{-1} \rangle = "ln" / \langle \gamma \rangle \quad (11)$$

where  $\langle \dots \rangle$  symbolizes the average over the quantum fluctuatuations of the quark in question in the nucleon, the proton say. The reason we have chosen the symbol " $ln$ " for this correction factor of order unity is that we expect that a contribution from the part of the wave function or better distribution of the quark energy in which it is accidentally slow will cause a logarithmically divergent contribution to  $\langle \gamma^{-1} \rangle$  in the limit of the quark mass going to zero. There is therefore expected a term at least in " $ln$ " that goes like the logarithm of the constituent mass of the quark meaning really its energy divided by the quark mass.

To get an idea of what our " $ln$ " shall be we have to imagine some - rather smooth of course - distribution of  $\gamma$  for the quark considered. This distribution must have the average, so that

$$\langle \gamma \rangle = \frac{m_{const}}{m_q}, \quad (12)$$

where  $m_{const} = E_q$  is the energy on the average of the quark inside the proton, say. It is also essentially the constituent mass in the quark model. The current algebra quark mass - and the one involved in the Higgs-Yukawa coupling - of the quark is called  $m_q$ .

Now it is impossible to have  $\gamma$  being less than unity, and we may use this fact together with a guess from smoothness of the statistical distribution of  $\gamma$  in the wave function of the quark inside the nucleon.

As a function of  $\gamma$  of course  $\gamma^{-1}$  is the inverse simply, and flat distribution would integrate up to give to  $\langle \gamma^{-1} \rangle$  essentially  $\ln(2 \langle \gamma \rangle) / (2 \langle \gamma \rangle - 1)$ . Using this estimate in our definition of " $ln$ " we would get the very crude estimate

$$"ln" \approx \langle \gamma \rangle \ln 2 \langle \gamma \rangle / (2 \langle \gamma \rangle - 1) \approx \frac{\ln(2 \langle \gamma \rangle)}{2 - \langle \gamma \rangle^{-1}} \approx \frac{\ln(2 \langle \gamma \rangle)}{2} \quad (13)$$

for big  $\langle \gamma \rangle$  as is indeed the case for quarks in nucleons.

With for instance a down quark mass being  $6MeV$  while using for the consituent mass or better the energy for a quark in the nucleon as being one third of the full mass say take  $330 MeV$  - or if one wants to give say half the energy to non-valence,  $165 MeV$ , we would then get

$$\langle \gamma \rangle \approx 330/6 = 55 \quad (14)$$

and with this value 55 we get by (13)

$$"ln" \approx \frac{\ln(2 * 55)}{2 - 55^{-1}} = \frac{4.70}{1.98} = 2.37 \quad (15)$$

If we used instead the value in which half the energy is in the non-valence quarks or gluons which are presumably the same for proton and neutron so that they do not contribute to the difference between them which is what we care for in the formula we are on the way to derive, we would get instead for the averga  $\gamma$

$$\langle \gamma \rangle \approx 165/6 = 27.5 \quad (16)$$

and with this value 27.5 we get by (13)

$$“ln” \approx \frac{\ln(2 * 27.5)}{2 - 27.5^{-1}} = \frac{4.01}{1.96} = 2.05. \quad (17)$$

(Had we used instead the small estimate of the down quark mass  $m_d = 3.5MeV$ , we would get the corresponding values for “ln” as 2.634 and 2.298.)

Since the only difference between a proton and a neutron is the exchange of one of the up-quarks in the proton by a down quark to make it a neutron, the difference in the  $S_I$  contribution is proportional to just the difference between the contributions for the quarks in quaestion. We thus obtain the equation needed to make the balance between the  $L_I$  contributions on the two sides of equation (2) for which we argued a finetuning to occur:

$$m_e + m_u * <\gamma^{-1}>_u = m_d * <\gamma^{-1}>_d. \quad (18)$$

By insertion we get from this equation then:

$$m_e + “ln”_u \frac{m_u^2}{m_{const}} = “ln”_d * \frac{m_d^2}{m_{const}}, \quad (19)$$

(where it is strictly speaking better to think of  $m_{const}$  as the energy of a quark inside the nucleon) or we can write it - assuming that the “ln” not depending much on the quark

$$m_e = “ln” * \frac{m_d^2 - m_u^2}{m_{const}}. \quad (20)$$

Insertion of say

$$m_d = 3.5MeV \text{ to } 6.0MeV \quad (21)$$

$$m_u = 1.5MeV \text{ to } 3.3MeV \quad (22)$$

$$m_e = 0.51MeV \quad (23)$$

$$m_{const} = 330MeV \text{ or } 165MeV \quad (24)$$

$$“ln” = 2.63 \text{ or } 2.05 \quad (25)$$

gives us the right hand side

$$r.h.s.(20) = 2.05 * \frac{36MeV^2 - 11MeV^2}{165MeV} = 0.31MeV \quad (26)$$

One might wonder about possible corrections to this first estimate. This agrees within 40 % with the actual elctron mass, which is better than the accuracy of our estimate so far.

It should be remarked though that, had we not made the assumption about the half of the energy being in non-valence partons, we would have got a worse agreement and predicted the electron mass about a factor 3 too low. Even that would though in the first run have been good enough.

Since indeed such a half of the energy being in the non-valence partons is phenomenologically about right we should take the agreement of our formula with experiment to be so good that it must be considered wellfunctioning.

In principle - but perhaps not in praxis - one might be able understanding and calculating with QCD or using phenomenological information to calculate much more precisely the average inverse  $\gamma$  and the quark mass to be used (e.g. the Yukawa couplings are running). By such a calculation we might hope in the future to check our prediction more precisely. The quark masses are not determined so accurately and it would be preferable if we could instead formulate our relation (19) as a relation involving the pion masses or the isospin breaking massdifferences directly.



## 5 How difficult to get the relation in other ways

It should be stressed that the here from the imaginary action model derived formula involves such quantities that it would be hard to see how it should come out of more conventional theory: In fact one could of course imagine that we could have a theory connecting the quark and electron masses, because they would be involved with the physics behind the Yukawa couplings, but it seems difficult to see how the mass of the proton or the neutron could come in too. The mass of the nucleons and thus the energy of the quarks in the nucleons are namely given mainly by the QCD- $\Lambda$ . This QCD -lambda must be extremely sensitively depending on the physics at the presumably very high energy scale at which the Yukawa couplings presumably get their values determined. Thus it would be rather accidental, if our formula should be obeyed for some other physical reason. So it would either be our derivation, or it would be just accidental.

## 6 The Cosmic Ray problem

It has been claimed that our model prediction of production of Higgs particles causing “bad luck”, meaning that such production should be prevented is already falsified by the fact that there are cosmic rays hitting the earth with such energy that certainly Higgses should be produced according to the Standard Model. It should, however, be understood that our model does *not* simply mean that such production will not occur at all, but rather that such production is potentially allowed to some extend provided it pays with respect to minimizing the “imaginary part of the action”  $S_I(history)$ . That is to say, that, if there were e.g. a mechanism for production of cosmic radiation, of which it would be almost impossible to get rid, by almost any “bad luck” however cleverly arranged, then such production would have to be there, basically because it cannot be prevented, unless the  $S_I$ -contribution from say big bang eras would have to be increased dramatically. The true prediction of our model will thus only be that Higgs production is brought to be so low as it can be *within the possibilities reachable without increasing  $S_I$  in some other era such as having Higgs production in an other era.*

In spite of our prediction being in this sense less strong than a total prevention of Higgs production we might still expect, that there would be some observable reduction of cosmic rays in the energy range that could lead to Higgs production. In the cosmic rays the amount of protons dominates over the amount of antiprotons and thus the Higgs production will be dominated by gluon collisions so that the Higgs production effectively only begins when the gluonic parton distribution function upper (approximate) edge reaches so high in energy that the Higgs with whatever mass it now may have get producable.

If we e.g. take the edge of the gluon distribution to lie at 0.1 and think of Higgs with mass 120 GeV then the effective threshold for Higgs production becomes at  $\sqrt{s} = 120\text{GeV}/0.1 = 600\text{GeV}$ , which in turn comes to mean that the beam energy  $E_{\text{threshold Higgs}}$  needed for production of Higgses is given by

$$E_{\text{threshold Higgs}} = \frac{s_{\text{threshold Higgs}} - 2m_p^2}{2m_p} = \frac{(600\text{GeV})^2 - 2\text{GeV}^2}{2\text{GeV}} = 1.8 \cdot 10^5 \text{GeV} = 1.8 \cdot 10^{14} \text{eV}. \quad (27)$$

Interestingly enough it now happens, that order-of-magnitudewise this threshold for Higgs production is very close to the already wellknown “knee” [20] at which the curve of the intensity of cosmic radiation as a function of the energy bends downward, so that indeed there is approximately a stop for the cosmic ray very roughly just at this Higgs producing threshold. The explanation[19] for this “knee” [20, 21] is presumably that the supernovae in the galaxy can only produce protonic cosmic ray up to this “knee”-energy of the order of  $10^{15}$  GeV; then it may still be possible to have from this supernovae source some higher-Z nuclei with energy above this “knee”. Indeed phenomenological evidence is that above the knee the cosmic ray particles are dominantly Fe-nuclei[21]. According to e.g. the plot in the article by Thomas K. Gaisser [18] arXiv:astro-ph/0608553v1 there is a “knee” at the energy  $2 \cdot 10^6 \text{GeV} = 2 \cdot 10^{15} \text{eV}$ . This is very much where we like to have it in order to just barely avoid the Higgs production.

One would almost say that the appearance of the “knee” just at this place - on an order of magnitudewise even very long curve of various energy scales having been investigated for cosmic rays - is almost remarkably good. So the knee should be considered a victory of our model!

In the philosophy of our model we should consider this closeness of the “knee” with the Higgs production threshold as not accidental, but rather e.g. the parameters or coupling constants or some details of

the history have been adjusted, so that the highest cosmic ray energies achievable by supernovae comes to be very close to the Higgs threshold. A priori it is only the initial conditions we have suggested to be fixed by the minimization of the “imaginary part of the action”  $S_I(histoty)$ , and that could imply that for instance the Hubble expansion rate could be what gets adjusted, but it seems to be a very attractive idea to allow the adjustment towards minimizing  $S_I$  not only to concern initial conditions, but also the coupling constants such as we have just seen above.

## 7 Estimation of the crucial number of Higgses to produce backward casation

In addition to the above mentioned problem of the cosmic ray Higgs production our complex action model also has the problem that the Tevatron at FNAL in Chicago (Batavia) presumably already has produced about say 10000 Higgses. Truly we do not know, if it has, because no Higgs bosons have been convincingly observed so far (i.e. in early 2010) and the mass of the Higgs is also known only through very uncertain indirect measurements. But if as is actually supported through a model supported by the picture connected with the complex action model of the present article [2] [17] the Higgs mass is equal to the lower bound for it in the Standard Model, then there would have been already produced according to the Standard Model several thousands Higgs bosons in the Tevatron. With such a low mass of the order of  $120\text{GeV}/c^2$ , however, even several thousands of Higgs produced would not have been seen yet.

If we shall uphold the model that Higgs particle production cause bad luck for the production machine we have therefore to withdraw to the position, that it is only a sufficiently big number of Higgs bosons being produced, that will cause sufficient effect to truly cause some visible change in the chance of the number being produced indeed.

### 7.1 How does the probability for bad luck depend on the number of Higgs bosons produced

A very naive and simple thought in our model gives immediately that as the Higgs boson living a time in its rest frame just on the average equal to the Higgs-life-time the suppression of the amplitude (3) occurs with a factor being

$$(\exp(-L_I(Higgs)\tau_{Higgs}))^{\#Higgses} = K^{\#Higgses}. \quad (28)$$

Here  $L_I(Higgs)$  is the contribution in the rest system of the Higgs from the Higgs particle, and  $\tau_{Higgs}$  is the average life time form for the Higgs particle, while  $\#Higgses$  denotes the number of Higgs bosons produced. Then the probability which goes as the numerical square this amplitude will also go with the number of Higgses  $\#Higgses$  in the exponent,  $(K^2)^{\#Higgses}$ .

This simple way of looking at it ignores the effect of the competition between different eras in governing the initial conditions. By the competition with the other eras the dependence of the initial conditions or equivalently the realized solution on what goes on in a given era (our era say) is brought appreciably down. It is, however, expected that inclusion of this era-competition-effect will change the constant  $K$  to be much closer to unity. If we therefore just define a phenomenological constant  $a = -\ln(K^2)|_{\text{after era-competition-correction}}$  we can crudely estimate the probability change to the usually expected probability distribution to say a card pull due to it being made responsible for the switch on or not of a Higgs-producing machine, such as LHC say.

Let us in fact imagine that we decided to pull a card from a usual card-deck and to let LHC be stopped, if we pull a black card while it gets allowed to run fully, if the card pulled is red. Then if our model of imaginary part in the action were not true, there would of course be 1/2 probability for red and 1/2 for black. If now our model were right, however, the non-normalized probability for the red card would be suppressed by a factor  $\exp(-a\#Higgses)$  relative to what it were without the effect of our imaginary part of the action. After normalization we would then get

$$\text{probability(red)} = \frac{1/2}{1/2 + 1/2 * \exp(-a\#Higgses)} = \frac{1}{1 + \exp(a\#Higgses)} \quad (29)$$

$$\begin{aligned} \text{probability(black)} &= \frac{1/2 * \exp(-a\#Higgses)}{1/2 + 1/2 * \exp(-a\#Higgses)} = \frac{1}{\exp(a\#Higgses) + 1} \end{aligned} \quad (30)$$

$$(31)$$

It is from these expressions clearly seen, that one *only gets a significant effect of the imaginary part of the action provided the product  $a\#Higgses$  is of order unity or bigger*. Thus the “phenomenological parameter”  $1/a$  becomes approximately the number of Higgses needed to produce in order to give any significant effect via our model. It is easy to see, that with usual or start probabilities  $P_s(\text{red})$  and  $P_s(\text{black})$  not equal the effect gets less easy to observe. In fact

$$\text{probability(red)} = \frac{P_s(\text{red})}{P_s(\text{red}) + P_s(\text{black}) * \exp(-a\#Higgses)} \quad (32)$$

$$\text{probability(black)} = \frac{P_s(\text{black}) * \exp(-a\#Higgses)}{P_s(\text{red}) + P_s(\text{black}) * \exp(-a\#Higgses)} \quad (33)$$

$$(34)$$

is calculated by correcting by the suppression factor and normalizing again to the total probability being unity.

## 7.2 Estimation of the “critical” amount of Higgses $1/a$ needed to cause any backward causation

From the well-running of the Tevatron so far (2010) we can conclude that the parameter  $1/a$  should not be terrible much smaller than the about 10000 which we may take as the order of magnitude for the number of Higgses having been produced by this Tevatron already. It can though be somewhat smaller since it is possibly difficult by adjusting the initial conditions to get such a machine prevented from getting built or to come to run.

Most important for saying something about our parametrization  $1/a$  of our effect is to see what we deduce about it by believing that the failure of SSC were indeed due to our effect. This must mean that indeed  $a\#Higgses$  were at least of order unity, but presumably preferably bigger than unity, where  $\#Higgses$  is taken to be *the number of Higgses that would have been produced in this SSC-accelerator*. According to one plan there is projected a development through 12 years of running (it is of course very difficult to know even for how long a successful SSC-accelerator would have been allowed to work in the hypothetical case, that it were not killed before working at all, but let us here for the estimation take these 12 years as a good estimate.). It should then have had luminosities starting at the first 0.5 year as  $10^{31} \text{cm}^{-2} \text{s}^{-1}$ , becoming at year 1  $10^{32} \text{cm}^{-2} \text{s}^{-1}$ , at year 2 a luminosity  $10^{33} \text{cm}^{-2} \text{s}^{-1}$ , at year 5 luminosity  $2.8 * 10^{33} \text{cm}^{-2} \text{s}^{-1}$ , reaching at year 10 the luminosity  $8 * 10^{33} \text{cm}^{-2} \text{s}^{-1}$ , ending with in the 12th year  $10^{34} \text{cm}^{-2} \text{s}^{-1}$ . Say that it from this would work in about the last 5 years with a little less than the luminosity  $10^{34} \text{cm}^{-2} \text{s}^{-1}$ ; it would say with a high proportion of time being working indeed have produced an integrated luminosity of the order a bit less than  $5 * 3 * 10^7 \text{s} * 10^{34} \text{cm}^{-2} \text{s}^{-1} = 1.5 * 10^{42} \text{cm}^{-2}$ . Let us say  $10^{42} \text{cm}^{-2} = 10^{18} \text{barn}^{-1} = 10^3 \text{fb}^{-1}$ .

Correspondingly one has for LHC thought of an integraget luminosity up to 2025 of  $5028 \text{fb}^{-1}$ , only deviating by a factor 5 from the expectation for SSC, LHC having w.r.t. integrated luminosity only a bit (a factor 5) bigger expectation than SSC.

At LHC at full energy  $7\text{TeV} + 7\text{TeV} = 14\text{TeV}$  and Higgs mass 120GeV a cross section of the order of  $30\text{pb}$  is expected for Higgs production. Thus at LHC if mainly running full energy we get *produced* - but certainly not all observed -  $5 * 10^3 \text{fb}^{-1} * 30\text{pb} = 1.5 * 10^7$  Higgs particles. At SSC the production would be somewhat bigger because of a higher cross section at the Hihger top energy  $20\text{TeV} + 20\text{TeV} = 40\text{TeV}$ . Even a factor 9 bigger crossection would only lead to similar order of magnitude of the total number of Higgses produced as in LHC, because of the higher luminosity of LHC, say a factor two more Higgses in all than at LHC.

If indeed LHC should ever come to produce more Higgses than SSC would have done - which though does not sound so easy according to the just given estimates - then the best evidence for our model, the failure of SSC would be lost and our model would, if not formally, then in praxis be falsified.

### 7.3 An estimate of the parameter $1/a$ for the crucial number of Higgses

However, we think we may get a true estimate of the order of magnitude for the significant number of Higgses  $1/a$  by making the assumption that it were not just accidental that at the moment, March 2010, LHC is running at  $3.5TeV + 3.5TeV = 7TeV$  rather than the schedule for full energy per particle  $7TeV + 7TeV = 14TeV$ , because of the physicists having been scared by troubles caused by the “God” in our model. If we in fact assume that there were organized - by our model initial conditions - some troubles connected with the incident more than one year ago, when there were the explosion in the tunnel causing, that for safety the LHC in this moment has to run at the half originally planned energy rather than at this full energy  $14TeV$  in center of mass, then it would mean that the “God” so to speak would *care for the Higgses potentially being produced in the supposedly 18 month periode concerned, if it had ran with the high energy per particle*. Actually we should more precisely say that this “God” would have to care even for the difference in numbers of Higgses produced at  $7TeV + 7TeV = 14TeV$  and the number produced at only  $3.5TeV + 3.5TeV = 7TeV$ . But that does not matter so much order of magnitudewise, because the number of Higgses at  $3.5TeV + 3.5TeV = 7TeV$  will be at least a factor 2 smaller than at the full energy, and thus the difference in number of Higgses will be order of magnitude of what is produced at the full energy of  $7TeV + 7TeV = 14TeV$ . That is to say order of magnitudewise we may estimate also the difference to represent about one or one and a half year of beginning Higgs production at full energy having the  $30pb$  as typical crosssection.

According to some old expectations one should have in LHC  $6fb^{-1}$  in 2009. Now let us interpret it to mean first running year and twice as much second year, which would integrate up to integrated luminosity after two first years of  $18fb^{-1}$ . It is presumably crudely o.k. then to think of  $10fb^{-1}$  as the integrated luminosity at the end of the presently going 18 month periode of running in 2010 to 2011.

The estimated number of would have been with full energy production in these first 18 month would thus be  $30pb * 10fb^{-1} = 3 * 10^5$  Higgses. We therefore would say that under this assumption of the scaring of the physicists to only work with half energy at the moment means that crucial number of Higgses  $1/a$  should be of the order of this number  $3 * 10^5$ .

If this

$$1/a \approx 3 * 10^5 \quad (35)$$

is indeed true then the SSC with its say  $3 * 10^6$  Higgses, it is 10 times as many, would almost certainly have to get stopped somehow if it were at all possible. It would namely have a suppression factor of the order

$$“SSCsuppresion” \approx \exp(-a * 3 * 10^6) = \exp(-10). \quad (36)$$

It should be stressed that this last case of “God” scaring the energy per particle down to the half value gives roughly the order of magnitude for the  $1/a$  parameter, because we truly have two number of Higgses being tested off - the high number not being allowed, and the one of the half energy being allowed, at least if LHC truly comes to run for of the order of the 18 months planned - and so it gives both upper and lower limit.

We thus really have at least this very weak argument in favour of  $1/a$  truly being of the order of 300000 Higgses.

So if some day LHC reaches to have produced appreciably more than these 300000 Higgses, then, although we could still screw up a bit our  $1/a$  to accomodate such a for our model bad happening, we would then loose the evidence we could now say we see for our model by the scaring down to half energy. So if LHC comes to produce more than these 300000 Higgses then we would loose this case of evidence and it would be so bad for our model, that we should essentially consider it a falsification of our model.

This falsification the just suggested way would occur about the 18 months after the restart after the updating to  $\sqrt{s} = 14TeV$  after the shut down after the present 18 months of running at the “low”  $\sqrt{s} = 7TeV$ . At that time we can write the paper about our model having been falsified. (I have been suggested this idea of having a falsification by Boerge Svane Nielsen)

## 8 Conclusion

We have reviewed a model by Ninomiya and myself based on the assumption of the fundamental theory being given by the Feynmann-Wentzel-Dirac path way integral in an interpretation involving the time at

all times including both past and future; *But most importantly we take the action to be complex!* In a suggestive approximation the model of ours, which turns out to be a model also for the initial conditions, suggests that the (true) solution of the classical equations of motion, through which we live, should be selected by the requirement of minimizing the imaginary part of the action  $S_I[history]$ , so that the latter is the smallest achievable for just this true history of the universe. This approximation may be described by an analogy to a skier with frictionless skies which after severe computer simulation calculations is being started with just the right speed and direction etc. so as to come through the according to the calculation absolutely most beautiful (when integrated up over time) tour. The integrated amount of beauty is in the analogy what corresponds to the imaginary part of the action  $S_I(history)$ . When the tour is constructed to completely optimize/maximize the integrated (amount of) beauty it is the tour analogous to the realized history of the universe (with its analogously minimized  $S_I(history)$ ). We should then find, if our model is true, that the likely features of such an optimized tour on ski can be very similar in an abstract way to what, we see our history of the Universe to be phenomenologically: If there were some place in the landscape that were so beautiful that any optimization hardly could avoid making the tour pass that spot, then the optimized tour would indeed pass that spot; but of course most likely the very most beautiful place would lie on a very steep hill side and it would not be possible to remain there for long with frictionless skies. This most beautiful place should be analogous to some time around the “big bang time”. If this biggest beauty region had so great beauty that it would dominate almost all the rest, we could get in the analogy that the big bang time would have a rather definite state, but that what goes on in other eras will then essentially be a consequence of what were to be organized in this crucial era around big bang, say to have on the to be realized history some special inflaton-field over an optimized long time. This picture favours a sort of bouncing-universe picture with the most important era “Big Bang time” - which does presumably not have a genuine Big Bang but only that the Universe were very small, but not necessarily zero, size - determines to a very large extend what goes on both before and after this era. We should then have in mind that, had we lived in the time before the “Big Bang” era, we would presumably have switched our notation under a timereversal symmetry and changed the notation from the story, that we live in a world preorganized to reach a special Big Bang situation with an extremely negative  $L_I$  and that we see order coming up (meaning entropy falling). It would have looked that things were getting prearranged so as to make this great event of the inflation like periode be possible with the extremely negative  $L_I$ . But we would easily have timereversed the notation and instead told the usual story that the inflation with the specially low (presumably very negative)  $L_i$  would be called to be in the past rather than in the future. In this way we could always interpret what happens by saying that on our side of the big bang era entropy grows and universe expands.

It has earlier been argued that the very likely the most important term in the imaginary part of the lagrangian - by a factor  $10^{34}$  we suggest - is the one coming from the imaginary part of the coefficient in the Higgs mass term, i.e. the term proportional to the Higgs field square. It has been remarked that once we identify this term as dominant there is no more so many parameters effectively in the imaginary part as in the real part, because now we can ignore all the many small terms in the imaginary part  $S_I$  and only care the one term proportional to the Higgs field square. This fact gives us better chance for getting predictions of a less general character. We namely know the  $S_I$  effectively under Standard Model conditions up to an over all coefficient.

For instance we can under the assumption of a limit of many parameters argue that there should be a minimum of  $S_I$  as a function of how the baryons are distributed (averaged over time) between protons and neutrons. The argument that it should indeed be so may not be quite watertight, but it could very likely happen that the direct effect of the number of baryons being there as protons versus those that are neutrons could become a significant term in the imaginary part of the action  $S_I$ . This would have caused there to be either almost no protons or almost no neutrons. To avoid such an incorrect scenario we reached the necessity of having a certain relation between the light quark masses and the electron mass. This relation (20) may also be written in the form

$$\sqrt{m_d^2 - m_u^2} = \sqrt{E_q * m_e} / \sqrt{\ln''}. \quad (37)$$

where we have used the notation  $E_q \approx m_{const}$  to stress that it is really the energy of the quark  $E_q$  in the frame of the nucleon that goes into our formula to give the  $\gamma$  for the quark which is the important thing. We used the energy of the valence quark being 1/6 of proton mass 1GeV and took 165 MeV, which then

gives using for the order unity quantity “ $ln'' \approx 2.05$  that we predict

$$\sqrt{m_d^2 - m_u^2} \text{‘predicted to’} 9.17/1.43 MeV = 6.41 MeV \quad (38)$$

to be compared to

$$\sqrt{m_d^2 - m_u^2} = \sqrt{3.5^2 - 1.5^2} MeV \text{ to } \sqrt{6.0^2 - 3.3^2} MeV = 3.16 MeV \text{ to } 5.01 MeV. \quad (39)$$

We stressed that taking this relation as a success can give a rather strong support for our model with imaginary part also for the action.. It would namely be very difficult for any competing theory to reproduce this relation, because it involves the QCD-scale, and it is really hard to see how that could be connected to the quark and electron masses in such a way as our relation (20,37) states. So our relation should be considered a support for our model of imaginary action with its prearrangements.

We also discussed the important problem with the cosmic rays, that should not hit the earth or other astronomical objects, if really Higgs production should be prevented. Of course it might be so difficult to switch off fully the high energy cosmic ray, so that a total cut off of the high energy spectrum would not pay in the attempt to minimize  $S_I$ . Very interestingly in this connection there is, however, as it has long been known at about the energy of the cosmic ray particle  $10^{15} eV$ , *which happens to be very close to the effective threshold for producing many Higgs particles*, a rather sharp fall off, more rapidly than at lower energies. This is what is known as the “knee” in the cosmic ray spectrum. As this spectrum has been studied well over several orders of magnitude, even the only order of magnitude coincidence of the energy scale at which Higgses begin to be produced copiously and the scale of the “knee” becomes somewhat remarkable! Did our imaginary action model indeed arrange that the main source of cosmic ray from supernovae in the galaxy just stops, where the Higgses begin to be produced copiously? The effect of this “knee” in suppressing the production of many Higgs bosons in hits on astronomical objects is further enhanced by the result [21].

## 8.1 Further study

Some of the fine tunings being possibly explained by some antropic principle derivation, might likely be instead explained by the  $S_I$ -minimization. For instance the existence of stable Helium-2[22][23] nucleus could potentially increase the rate of star development appreciably by making the weak interaction proton-proton process starting the nuclear formation process in the stars be replaced by the electromagnetic formation of Helium-2. If there were such an effect the fact that the Helium-2 nucleus is just very barely unstable and thus useless in the star development could be considered a result of our model. In fact our minimization of  $S_I$  would be seeking to delay the formation of black holes with lot of high energy physics going on such as e.g. Higgs production. Now, however, Bradford[24] has pointed out that in contrafactual world with a stable Helium-2 stars with similar life times as they have the real world are not excluded. So the argument is not necessarily so simple; but in our model whenever something dramatically would happen by varying a coupling there is a high chance that it would cause alsos dramatic effects on  $S_I$  and at the end drive the history of the universe and probably even the couplings to adjust into neighborhood of the dramatic shift.

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# Remarkable Relation from Minimal Imaginary Action Model \*

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## Abstract

If it is to be true that the history of the universe should minimize the “imaginary part of action” [1] [2] it would be “easiest” to have this “imaginary part of the action” to be rather independent of whether the neutrons are converted to electrons and protons (and neutrinos), and therefore of whether the contribution to the imaginary part of the Lagrangian were conserved under this conversion. Under the further assumption - which is reasonable - that the by far dominant term in the imaginary part of the Lagrangian density is the one corresponding to the Higgs mass square term in the Standard Model Lagrangian density  $m_H^2 |\phi(x)|^2$  we derive a relation

$$\sqrt{m_d^2 - m_u^2} = \sqrt{m_{\text{constituent}} * m_e} / \sqrt{\text{“}ln\text{”}} \quad (1)$$

where “ $ln$ ” is defined by  $\langle \gamma^{-1} \rangle = \text{“}ln\text{”} / \langle \gamma \rangle$  and is of the order of 1 to 4, where  $\gamma$  stands for relativity  $\gamma$  of a valence quark inside a nucleon. This relation is very well satisfied with the phenomenologically estimated current algebra quark masses  $m_u$ ,  $m_d$ , and the constituent mass  $m_{\text{constituent}}$  for the light quarks, taken say to be one third of the nucleon mass.

Our model has been criticised on the ground that it should have prevented cosmic rays with energies capable of producing Higgs particles, when hitting say the atmosphere. Indeed there is, however, a well known “knee” in the density curve as function of energy at an order of magnitude for the cosmic ray particle energy close to the effective threshold for Higgs production.

A parameter giving the order of magnitude of number of Higgses to be produced in order to get a significant effect is estimated to be about  $3 * 10^5$ .

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# 1 Introduction

Recently Ninomiya and I [1][2] have put forward after some thinking on time machines [3] a model in which the action - of the Standard Model say - gets provided with an imaginary part. This having a model for the *initial conditions* is also a subject already touched upon by me and Bennett much earlier [5][4]. It were suggested that the term in the Lagrangian density corresponding Higgs mass square  $m_H^2 |\phi(x)|^2$  should dominate the imaginary part and that leads to the main effect of the model being to predict that accelerators producing large amounts of Higgs particles should be likely to have bad luck in the sense of not coming to fully work.

It is a major point of the present article to point out that with the actually natural assumption of the Higgs mass square term dominating the number of parameters in the imaginary part of the action is formally reduced to the imaginary part  $m_H^2|_I = Im(m_h^2)$  of the mass square term coefficient. In reality the exact variation of the integrated square of the Higgs field might be not completely easy to evaluate and a few parameters parametrizing the difficulties in performing calculations which in principle can be done might have to be included into the model.

We have in earlier works already argued, that for a situation with only massless and conserved non-relativistically moving particles the effects of the situation on the imaginary action  $S_I(history)$  become trivial and thus there will be in this approximation no effect of the requirement predicted by our model for governing the initial conditions of the universe so as to arrange that what really happens minimizes this imaginary part of the action  $S_I(history)$ .

We should thus only make unusual predictions when either

- a) Some particles are not either massless or non-relativistic, (In that case namely a more complicated form for the eigentime for such particles would appear, than for massless or non-relativistic particles with the eigentimes being respectively zero and equal to the usual coordinate time; more complicated eigentime would mean also more complicated action, say the imaginary part, because the action goes as the eigentime.) or
- b) Some particles are not conserved, but say converted into each other or simply appear or disappear. (Such decay or appearance would of course make the to the action connected eigentime depend on when the appearance and decay occurs so that the history would influence the (imaginary) action under such conditions)

The point of the trivial contributions to the “imaginary part of the action” when the two mentioned deviations from daily life physics are avoided is easily understood by noting that the action - it being the real of the imaginary part - of a propagating particle, say from one interaction to the next, is a constant times the (relativistic)eigentime:

We namely then immediately see that at least between the interactions - and interactions will in daily life physics take up a relatively short time compared to the free times - the massless particles contribute zero because their eigentimes are zero, and the non-relativistically conserved particles contribute just proportional to the frame time in the frame in which they are non-relativistic, provided of course that they are conserved so that they are indeed present at all times.

In the so to speak daily life approximation we only meet protons, neutrons, electrons and massless particles meaning mainly the photon. Among these particles only the nucleons attain velocities approaching relativistic speeds inside the nuclei, which themselves are only seldomly converted into each other. As long as the nuclear reactions do not occur and the motions of the particles remain non-relativistic the imaginary action contributions remain trivial to good approximation and severe governing of the universe effect such as some apparatuses having “bad or good luck” should not occur.

Astronomically there does, however, occur some transformations of electrons plus protons into neutrons and neutrinos. Since the neutrinos are to first approximation massless they should not contribute to the imaginary part of the Lagrangian for that reason. But a priori, unless the contributions to the imaginary part of the Lagrangian of a neutron were almost miraculously tuned in to be the same as that from the electron and the proton together there would be a significant change in the imaginary part of the lagrangian  $L_i$  each time the reaction

$$e + p \leftrightarrow n + \nu_e \tag{2}$$

runs one way or the other.

It is the main point of the present article to argue for that it could be likely that the minimization of  $S_I$  would lead to a tune in of parameters that would organize this transition  $e + p \leftrightarrow n + \nu_e$  to *not* change the  $L_I$ . The idea is in the direction that other features of the initial conditions can be adjusted more freely without having to take care of their influence on the amount of transitions of this type of “neutron decay” taking place or at what time they take place.

For the argument for this sort of finetuning being likely to occur we refer to section 3.

## 2 Review of our Imaginary part of Action Model

One may formulate the model by M. Ninomiya and myself [1] by saying that we use a certain way of interpreting the Feynman-Dirac-Wentzel path way integral (a bit different from the usual use) we assume that the action  $S[path]$  has also *an imaginary part*. This means of course that we write the action  $S$  to put into the Feynman path way integral

$$\int \exp(\frac{i}{\hbar} * S[path]) \mathcal{D}path \quad (3)$$

as

$$S[path] = S_R[path] + iS_I[path] \quad (4)$$

where of course  $S_I[path]$  is the imaginary part, which is zero in the usual theory, but assumed to be a functional of quite similar, but not identical, form to that of the real part  $S_R[path]$ .

It is immediately obvious that, while in the usual theory in which there is no imaginary part of the action, i.e.  $S_I[path] = 0$ , the integrand of the path way integral  $\exp(\frac{i}{\hbar} * S[path])$  is a complex number with unit numerical value, the inclusion of our imaginary part makes the integrand able to take a pathdependent numerical value. In fact it is seen that assuming the imaginary part to be a priori of a similar order of magnitude as the real part of the action and remembering that compared to daily life, when classical approximation is often good enough, the Planck constant  $\hbar$  is in principle small the suppression of the integrand for positive  $S_I[path]$  and the enhancement for negative  $S_I[path]$  are enormous. Without further details this clearly points towards the idea that the paths which do not have their  $S_I[path]$  being minimal inside the range of paths not brought to be made irrelevant for other reasons must come to dominate the path way integral.

Now it is wellknown that one can in the usual path way integral formulation argue for the classical equations of motion to appear as a saddle point approximation in the evaluation of the Wentzel-Feynman-Dirac path way integral. Basically the idea in the derivation from the path way integral of the classical equations of motion comes from that unless we sum up the different path contributions in the neighborhood of a path for which the variation of the action is zero

$$\delta S[path] = 0 \quad (5)$$

the phase of the integrand will vary over the neighboring region of that path so fast, that essentially the contributions cancel out, and we get very little resulting contribution from the neighborhood of such a path.

Very crudely we might take this phase variation argument to mean that only the neighborhood of paths for which

$$\delta S_R[path] = 0 \quad (6)$$

will survive (i.e stay making a significant contribution to the path way integral) and that then the *path which among these classical solutions* have the minimal value for  $S_I[path]$  will dominate. This approximation strictly speaking does not work when the  $S_I$  gets big, but we believe to have arguments that it will work approximately in practice.

## 2.1 We include the future

A most important point in our way of applying the path way integral compared to what is usually done is that we *include the contributions from the future* into the integral form of the action

$$S[path] = \int_{-\infty}^{\infty} L(path(t), \frac{dpath(t)}{dt}) dt. \quad (7)$$

This inclusion of the future has the very important consequence that the question as to which path inside, say the class of those ones obeying the classical equations of motion, gets the minimal value of the imaginary part of the action  $S_I[path]$  and thus should be the most important path depends not only on what goes on along this path in the past, but also *in the future*. That has the consequence that it will look in our model as if the initial conditions have been *selected with some purposes of arranging in the future some happenings that could make especially numerically big but negative contributions to  $S_I[path]$* . Such prearrangements to obtain especially negative contributions to  $S_I$  even from the future will be conceived of as *miraculous coincidences seemingly made with a purpose*. Provided our speculation that especially the production of Higgs bosons in large numbers should cause exceptionally large positive contributions to the imaginary part of the action  $S_I$  we expect the typical miraculous coincidences of this type to be the coincidences of small bad lucks leading to that a great accelerator meant to produce a lot of Higgs bosons after all gets in trouble and does not at the end come to work. We have since long proposed that the case of the stopping in 1993 of the budgets for the SSC (= Superconducting Supercollider in Texas) by the U.S. Congress were a case of such a prearranged set of coincidences “made up” to stop the potential great amount of Higgs bosons being produced.

## 2.2 The classical approximation law of initial conditions

As we have just stated the bunch of paths that will dominate the Feynman-Wentzel-Dirac path integral in our model with its complex action is expected to be

- 1) a bunch around a classical solution (since otherwise the phase from the integrand corresponding to the different paths in the bunch would vary so as to make the contribution of the bunch wash out)
- 2) the bunch of this type having the minimal - in the sense of being most negative - imaginary part of the action  $S_I(history)$ .

Supposing that the point 1) can be apprimated by just including the real part of the action and taking the usual classical equation of motion written in the usual extremizing the action way,

$$\delta S_R = 0, \quad (8)$$

the point 2) takes formally the form of a minimization among all the classical solutions

$$LAW\ OF\ INITIAL\ CONDITIONS : \quad (9)$$

$$S_I(history)\ MINIMAL. \quad (10)$$

This is much like a law of “the will of “God” ”.

## 2.3 Suppression of the effect of the imaginary part $S_I$

Both for the performance of the argument for the main effect indeed being of the form that the classical solution selected to be realized is the one with the minimal imaginary part of the action  $S_I$  and for obtaining agreement with the phenomenological fact that after all we see extremely few - if at all any - prearranged events we need for our model to be viable that in some way effectively the imaginary is small. By prearranged event we here meant that we should see something requiring an explanation involving special finetuning of initial conditions so as to arrange some special thing to happen later. Even if we would count the failure of the SSC machine as such a case and include some miracles from the bible etc. such events - which might be called cases of backward causation - are extremely rare.

So we have in our model the problem that we either have to assume that even if there is an imaginary part of the action then it is very small, or we have to present a mechanism, that even if there is a priori say an imaginary part of the action being of the same order as the real one, then in practice we shall see effects only as if it were much smaller.

### 2.3.1 An important argument for suppressing the effect of the imaginary part of the action

The argument for suppressing the effect to which we have most hope is of the type that each period of time, each era, cannot have very much say about the initial conditions, because there is only one set of initial conditions to determine what happens in all the many eras through the history of the Universe:

One may see each era in the development of the Universe as having different developments, all being though described according to the equations of motion being integrated up from the same initial conditions. It is the same equation of motion solution that must describe what goes on in all eras from the earliest times to the latest times. Since the solutions are so to speak in one to one correspondence with the state (in phase space) at one moment of time there are of course not freedom enough to adjust for the optimal (meaning  $S_I$  being minimal) happening for all the many eras with the same solution. Rather the minimization of the imaginary part of the action  $S_I(history)$ , which is an integral over all times, must be determined as a compromise between “wishes” from the many different eras. But that will then in each separate era make events happen that do not precisely make the  $S_I$ -contribution from just that era become minimal. Rather it would look from the point of view of one single era as if what happens is mainly determined from the influence on the choice of solution from quite different eras. Really to make our model match with phenomenological facts we must hope that for some reason in our model the era of the big bang time contributes especially strongly to  $S_I$  so that what we observe will in first approximation look like being determined by organization of an arrangement of what went on in the Big Bang time(s). Thereby it will namely come to look as if the past is fixed so as to fulfill some - especially negative  $L_I$  - story during that era, and then we mainly just “see” the essentially unavoidable development of this in a big bang era fixed solution to the equations of motion.

## 3 The need for $L_I$ being insensitive to Neutron decay or its inverse

### 3.1 Selection of initial state may in many cases lead to selection of coupling constants in practice!

A priori our model predicts that the minimization of the imaginary part  $S_I(history)$  occurs by selecting the *history* by selecting the initial conditions mainly. Contrary to that we at first should think of the coupling constants and parameters such as masses as being fixed by nature in a different way, a priori. However, there are ways in some models such as baby-universe theory that initial condition given quantities could achieve to influence the world effectively as if the parameters as coupling constants etc. were dependent on the initial conditions and thus in our model also should be adjusted - at least to some extent - to minimize  $S_I$ , to some extent as if this  $S_I$  also depended on some parameters parametrizing the coupling constants and mass-parameters.

In arguing for how the parameters, such as coupling constants masses etc., might be adjusted to the degree that they are accessible to being changed in the procedure of minimizing “the imaginary part of the action”  $S_I(history)$  we could imagine a picture, that the vacuum has a very complicated structure with many fields, that could be adjusted from the start and then would stand so further on. Then namely the adjustment of the initial situation w.r.t. these “parameters of the vacuum” could cause an effective way of getting the minimization of  $S_I$  also determine - still may be within some restrictions though - the coupling constants and mass parameters etc.

The obvious example of that kind of adjustable vacuum would in practice be the “landscape” ideas[?]: In superstring theory there are so many ways of compactifying extra dimensions in detail that one has a huge number of possible effective theories in the low energy fourdimensional approximation. These hugely many have at least some stability so that the one that gets installed will stay for long time. Thus

precisely which vacuum gets installed in the beginning will determine which vacuum and thus which effective couplings will be realized over later times.

So we must imagine that in our model the vacuum to survive will be selected to be the one or one of the ones with the lowest imaginary part of the Lagrangian density \* up to some corrections from the behavior of the material getting present in this vacuum. Since at least phenomenologically to day most of the universe is extremely empty one would expect that the selection of the one of the vacua with the lowest \* and thereby effectively of the effective coupling constants for the effective fields in this vacuum would play a very important role in settling the initial conditions minimizing the imaginary part of the action  $S_I$ .

But if there are indeed a very huge number of vacua to choose between it could turn out that it would not necessarily be exactly the vacuum with the lowest Lagrangian density in the very vacuum situation  $\downarrow \Downarrow \Downarrow [\lceil \neg \rceil \sqsubseteq \neg] \cap \cap \Downarrow$  which would be selected, but that a history with a bit lower  $S_I$ -contribution from the matter and radiation etc could compete if the difference in vacuum contributions is small.

### 3.2 The balance

Think of there being a set of parameters that are accessible to being tuned on to vary  $S_I$  and then we know the realized choice should be one with  $S_I$  having been minimized. Corresponding to a set of parameters we imagine that there is then a history of the universe development and especially say the total number of neutrons existing inside or outside the nuclei at each moment of time would have some value depending on the history in question. Then one could especially think of extracting for such a history the collected existence time for all the neutrons  $T_{neutrons} = \sum_i t_i$ , meaning the sum of the time of existence  $t_i$  of all the neutrons, indexed by  $i$  exist for some time in the world (free or inside the nuclei in which there stability has been increased to infinite stability usually). It should be emphasized that this “existence time of all the neutrons  $T_{neutrons} = \sum_i t_i$  is concerned with mostly *neutrons bound into nuclei*, while free neutrons are so seldom in praxis in our universe that they play practically no role in comparizon. We are dominantly concerned with neutrons stabilized (almost) completely by being bound into nuclei.

We might even think of this collected lifetime of all the neutrons  $T_{neutrons}$  as one of the adjustable parameters, if we wish to do so. But if we think this way, then assuming a smooth behavior of the  $S_I$  to be minimized as function of the parameters we should deduce that the *derivative* of  $S_I$  w.r.t. the collected neutron existence time  $T_{neutrons}$  should be *zero*. This is just the usual rule of the derivative being zero at a minimum. Now most of the contribution to the collective neutron existence time comes presumably from the era which is dominated by the physics of “dayly life” as we called it above. Now when we think of varying the collected neutron existence time it will of course occur by shifting the transformation of the neutrons to proton plus electron under absorbtion of the neutrino or opposite earlier or later in the history *history*. The effect of such a change in the history - by changing some parameters - will change the total  $S_I(history)$  for two sorts of reasons:

- 1 There will simply be the change due to the difference in the  $L_I$  coming from proton + electron versus that from neutron + electronneutrino.
- 2 There will be all the other changes caused by the shift in the variables that were to be changed in order to arrange for the change in the neutron collective existence time  $T_{neutrons}$  we wanted to change. A priori this change could be big, because changing the parameters will typically change e.g. the imaginary part of the vacuum Lagrangian density  $\mathcal{L}_{\mathcal{I}}$ , and since there is a huge amount of vacuum this could be very big amounts of  $S_I$ -contribution. However, now we want to argue that we have the freedom when discussing how to produce a given little change in the collected neutron existence time  $T_{neutrons}$  to choose which parameter to use. If there are many possible parameters to vary - or for some reason there are great chance that the choice of parameter can lead to very small effect on  $S_I$  if the parameter is chosen appropriately -, then we could choose likely the parameter to play with to cause only small influence on  $S_I$  via other effects than just via the collected neutron existence time.

If we indeed take the choice among many parameters to vary when thinking of varying the collected neutron existence time to minimize the variation of  $S_I$  described under point 2, then we may argue that

the variation under point 1 will dominate. The latter is, however, *calculable* in principle, since we have assumed the  $L_I$  to be dominated by the term in the imaginary part of the Lagrangian density, which is proportional to the Higgs field square - we argued in fact for the imaginary coefficient part of the Higgs mass term to dominate-. But this then means the variation due to the change - as under item 1 - in the collected neutron existence by itself shall be zero. Now this change in  $S_I$  is proportional to the difference in  $L_I$  for a resting (or just non-relativistic) proton plus a resting electron relative to that of a resting neutron. The neutrino is massless and we ignore its  $L_I$ -contribution. Therefore the argumentation from the minimization of  $S_I$  leads to that this difference must have been adjusted - somehow or another - to be zero.

This is the basis for the relation which is the main result of the present article, i.e. our prediction comes from the imaginary action being minimized w.r.t. the collected neutron life time  $T_{neutrons}$  and thus having zero derivative.

Even if the above argument for the zero derivative of  $S_I$  w.r.t.  $T_{neutrons}$  and thus the change in  $L_I$  under neutron decay being zero were not convincing from a completely theoretical point of view, we can at least note phenomenologically, that there is in nature today both neutrons and neutron-decay products, protons and electrons (and (anti)neutrinos) in comparable amounts. If indeed there were a difference in the imaginary part of the Lagrangian  $L_I$  for the neutron and its decay products then it should in our model go so that either all the neutrons disappeared or all the protons and electrons were made into neutrons. Neither of these two predicted possibilities seem to have been even approximately realized in nature. Thus our model will be in trouble unless the change in  $L_I$  under neutron decay is indeed zero. With the enormous amounts of neutrons in the world one would get an enormous effect of selection of the history with an exponentially easily enormous factor.

## 4 The interesting relation

Now we shall evaluate the difference between the  $L_I$ -contribution of the two pairs of particles on the sides of the equation (2) because that is what we predict to be zero.

Now we have that the main interaction with the Higgs field of some particle such as a quark or an electron simply comes via the Yukawa coupling which in turn is proportional to the mass of the particle in question. Since we have hypothesised, that it is the square of the Higgs field, which gives us the  $L_I$  dominant term, and we expect for small interactions that this square will vary proportional to the Yukawa coupling, we expect that the contribution from the passage, of a quark say, by multiplying the eigentime for the periode considered with the mass of the quark

Since a similar relation holds for the electron, say, we can thus see that for a non-relativistic electron the contribution to  $L_I$  is simply proportional to the electron mass  $m_e$ . With same proportionality the contribution to the  $L_I$  from a non-relativistic proton say will of course get three contributions one from each of the three quarks, but now these quarks are not non-relativistic but rather move most of the time pretty relativistically. Rather we have that the amount of eigentime spent per unit time in the rest frame of the proton is proportional  $\gamma^{-1}$ , where  $\gamma$  is the relativistic  $\gamma$ -factor for the quark (in the proton system). Of course this eigentime correction factor  $\gamma^{-1}$  fluctuates quantum mechanically and in reality has a distrubtuion rather than a special value. Nevertheless we expect that very crudely it behaves similarly to the inverse of the average of the  $\gamma$ -factor itself, and we have found it suitable to define a factor of order unity “ln” by the relation

$$\langle \gamma^{-1} \rangle = \text{“ln”} / \langle \gamma \rangle \quad (11)$$

where  $\langle \dots \rangle$  symbolizes the average over the quantum fluctuatuations of the quark in question in the nucleon, the proton say. The reason we have chosen the symbol “ln” for this correction factor of order unity is that we expect that a contribution from the part of the wave function or better distribution of the quark energy in which it is accidentally slow will cause a logarithmically divergent contribution to  $\langle \gamma^{-1} \rangle$  in the limit of the quark mass going to zero. There is therefore expected a term at least in “ln” that goes like the logarithm of the constituent mass of the quark meaning really its energy divided by the quark mass.



To get an idea of what our “ $ln$ ” shall be we have to imagine some - rather smooth of course - distribution of  $\gamma$  for the quark considered. This distribution must have the average, so that

$$\langle \gamma \rangle = \frac{m_{const}}{m_q}, \quad (12)$$

where  $m_{const} = E_q$  is the energy on the average of the quark inside the proton, say. It is also essentially the constituent mass in the quark model. The current algebra quark mass - and the one involved in the Higgs-Yukawa coupling - of the quark is called  $m_q$ .

Now it is impossible to have  $\gamma$  being less than unity, and we may use this fact together with a guess from smoothness of the statistical distribution of  $\gamma$  in the wave function of the quark inside the nucleon.

As a function of  $\gamma$  of course  $\gamma^{-1}$  is the inverse simply, and flat distribution would integrate up to give to  $\langle \gamma^{-1} \rangle$  essentially  $\ln(2 \langle \gamma \rangle) / (2 \langle \gamma \rangle - 1)$ . Using this estimate in our definition of “ $ln$ ” we would get the very crude estimate

$$“ln” \approx \langle \gamma \rangle \ln 2 \langle \gamma \rangle / (2 \langle \gamma \rangle - 1) \approx \frac{\ln(2 \langle \gamma \rangle)}{2 - \langle \gamma \rangle^{-1}} \approx \frac{\ln(2 \langle \gamma \rangle)}{2} \quad (13)$$

for big  $\langle \gamma \rangle$  as is indeed the case for quarks in nucleons.

With for instance a down quark mass being  $6MeV$  while using for the constituent mass or better the energy for a quark in the nucleon as being one third of the full mass say take  $330 MeV$  - or if one wants to give say half the energy to non-valence,  $165 MeV$ , we would then get

$$\langle \gamma \rangle \approx 330/6 = 55 \quad (14)$$

and with this value 55 we get by (13)

$$“ln” \approx \frac{\ln(2 * 55)}{2 - 55^{-1}} = \frac{4.70}{1.98} = 2.37 \quad (15)$$

If we used instead the value in which half the energy is in the non-valence quarks or gluons which are presumably the same for proton and neutron so that they do not contribute to the difference between them which is what we care for in the formula we are on the way to derive, we would get instead for the average  $\gamma$

$$\langle \gamma \rangle \approx 165/6 = 27.5 \quad (16)$$

and with this value 27.5 we get by (13)

$$“ln” \approx \frac{\ln(2 * 27.5)}{2 - 27.5^{-1}} = \frac{4.01}{1.96} = 2.05. \quad (17)$$

(Had we used instead the small estimate of the down quark mass  $m_d = 3.5MeV$ , we would get the corresponding values for “ $ln$ ” as 2.634 and 2.298.)

Since the only difference between a proton and a neutron is the exchange of one of the up-quarks in the proton by a down quark to make it a neutron, the difference in the  $S_I$  contribution is proportional to just the difference between the contributions for the quarks in question. We thus obtain the equation needed to make the balance between the  $L_I$  contributions on the two sides of equation (2) for which we argued a finetuning to occur:

$$m_e + m_u * \langle \gamma^{-1} \rangle_u = m_d * \langle \gamma^{-1} \rangle_d. \quad (18)$$

By insertion we get from this equation then:

$$m_e + “ln”_u \frac{m_u^2}{m_{const}} = “ln”_d * \frac{m_d^2}{m_{const}}, \quad (19)$$

(where it is strictly speaking better to think of  $m_{const}$  as the energy of a quark inside the nucleon) or we can write it - assuming that the “ $ln$ ” not depending much on the quark

$$m_e = “ln” * \frac{m_d^2 - m_u^2}{m_{const}}. \quad (20)$$

Insertion of say

$$m_d = 3.5MeV \text{ to } 6.0MeV \quad (21)$$

$$m_u = 1.5MeV \text{ to } 3.3MeV \quad (22)$$

$$m_e = 0.51MeV \quad (23)$$

$$m_{const} = 330MeV \text{ or } 165MeV \quad (24)$$

$$“ln” = 2.63 \text{ or } 2.05 \quad (25)$$

gives us the right hand side

$$r.h.s.(20) = 2.05 * \frac{36MeV^2 - 11MeV^2}{165MeV} = 0.31MeV \quad (26)$$

One might wonder about possible corrections to this first estimate. This agrees within 40 % with the actual elctron mass, which is better than the accuracy of our estimate so far.

It should be remarked though that, had we not made the assumption about the half of the energy being in non-valence partons, we would have got a worse agreement and predicted the electron mass about a factor 3 too low. Even that would though in the first run have been good enough.

Since indeed such a half of the energy being in the non-valence partons is phenomenologically about right we should take the agreement of our formula with experiment to be so good that it must be considered wellfunctioning.

In principle - but perhaps not in praxis - one might be able understanding and calculating with QCD or using phenomenological information to calculate much more precisely the average inverse  $\gamma$  and the quark mass to be used (e.g. the Yukawa couplings are running). By such a calculation we might hope in the future to check our prediction more precisely. The quark masses are not determined so accurately and it would be preferable if we could instead formulate our relation (19) as a relation involving the pion masses or the isospin breaking massdifferences directly.

## 5 How difficult to get the relation in other ways

It should be stressed that the here from the imaginary action model derived formula involves such quantities that it would be hard to see how it should come out of more conventional theory: In fact one could of course imagine that we could have a theory connecting the quark and electron masses, because they would be involved with the physics behind the Yukawa couplings, but it seems difficult to see how the mass of the proton or the neutron could come in too. The mass of the nucleons and thus the energy of the quarks in the nucleons are namely given mainly by the QCD- $\Lambda$ . This QCD -lambda must be extremely sensitively depending on the physics at the presumably very high energy scale at which the Yukawa couplings presumably get their values determined. Thus it would be rather accidental, if our formula should be obeyed for some other physical reason. So it would either be our derivation, or it would be just accidental.

## 6 The Cosmic Ray problem

It has been claimed that our model prediction of production of Higgs particles causing “bad luck”, meaning that such production should be prevented is already falsified by the fact that there are cosmic rays hitting the earth with such energy that certainly Higgses should be produced according to the Standard Model. It should, however, be understood that our model does *not* simply mean that such production will not occur at all, but rather that such production is potentially allowed to some extend provided it pays with respect to minimizing the “imaginary part of the action”  $S_I(history)$ . That is to say, that, if there were e.g. a mechanism for production of cosmic radiation, of which it would be almost impossible to get rid, by almost any “bad luck” however cleverly arranged, then such production would have to be there, basically because it cannot be prevented, unless the  $S_I$ -contribution from say big bang eras would have to be increased dramatically. The true prediction of our model will thus only be that Higgs production

is brought to be so low as it can be *within the possibilities reachable without increasing  $S_I$  in some other era such as having Higgs production in an other era.*

In spite of our prediction being in this sense less strong than a total prevention of Higgs production we might still expect, that there would be some observable reduction of cosmic rays in the energy range that could lead to Higgs production. In the cosmic rays the amount of protons dominates over the amount of antiprotons and thus the Higgs production will be dominated by gluon collisions so that the Higgs production effectively only begins when the gluonic parton distribution function upper (approximate) edge reaches so high in energy that the Higgs with whatever mass it now may have get producable.

If we e.g. take the edge of the gluon distribution to lie at 0.1 and think of Higgs with mass 120 GeV then the effective threshold for Higgs production becomes at  $\sqrt{s} = 120\text{GeV}/2/0.1 = 600\text{GeV}$ , which in turn comes to mean that the beam energy  $E_{\text{threshold Higgs}}$  needed for production of Higgses is given by

$$E_{\text{threshold Higgs}} = \frac{s_{\text{threshold Higgs}} - 2m_p^2}{2m_p} = \frac{(600\text{GeV})^2 - 2\text{GeV}^2}{2\text{GeV}} = 1.8 \cdot 10^5 \text{GeV} = 1.8 \cdot 10^{14} \text{GeV}. \quad (27)$$

Interestingly enough it now happens, that order-of-magnitudewise this threshold for Higgs production is very close to the already wellknown “knee” [21] at which the curve of the intensity of cosmic radiation as a function of the energy bends downward, so that indeed there is approximately a stop for the cosmic ray very roughly just at this Higgs producing threshold. The explanation[19] for this “knee” [21, 22] is presumably that the supernovae in the galaxy can only produce protonic cosmic ray up to this “knee”-energy of the order of  $10^{15}$  GeV; then it may still be possible to have from this supernovae source some higher-Z nuclei with energy above this “knee”. Indeed phenomenological evidence is that above the knee the cosmic ray particles are dominantly Fe-nuclei[22]. According to e.g. the plot in the article by Thomas K. Gaisser [18] arXiv:astro-ph/0608553v1 there is a “knee” at the energy  $2 \cdot 10^6 \text{GeV} = 2 \cdot 10^{15} \text{eV}$ . This is very much where we like to have it in order to just barely avoid the Higgs production.

One would almost say that the appearance of the “knee” just at this place - on an order of magnitudewise even very long curve of various energy scales having been investigated for cosmic rays - is almost remarkably good. So the knee should be considered a victory of our model!

In the philosophy of our model we should consider this closeness of the “knee” with the Higgs production threshold as not accidental, but rather e.g. the parameters or coupling constants or some details of the history have been adjusted, so that the highest cosmic ray energies achievable by supernovae comes to be very close to the Higgs threshold. A priori it is only the initial conditions we have suggested to be fixed by the minimization of the “imaginary part of the action”  $S_I(\text{histoty})$ , and that could imply that for instance the Hubble expansion rate could be what gets adjusted, but it seems to be a very attractive idea to allow the adjustment towards minimizing  $S_I$  not only to concern initial conditions, but also the coupling constants such as we have just seen above.

## 6.1 More accurate estimate of the effective Higgs production threshold

Since the “knee” happens to be so close to the effective threshold for Higgs production, it becomes interesting to define and estimate this Higgs-production threshold a bit more accurately. There is not truly any threshold for Higgs production in the range of energies, where there is any significant chance for producing Higgses at all. For instance for the Higgs mass expected in the type of model connected with the present article 120 GeV the formal Higgs threshold in terms of  $\sqrt{s}$  would only be a couple GeV more than the mass 120 GeV of the Higgs, since it would only be needed to have in addition to the Higgs two protons for baryon number and charge conservation. At this energy there is, however, no Higgs production at all in practice. Indeed the Higgs production cross section has a very tiny tail at low energy between the formal threshold and a much higher square root  $s$  closer to the Tevatron or LHC energies. Let us therefore define for each mass possibility for the Higgs  $m_H$  an “effective Higgs production threshold” by a linear extrapolation from above in energy (above the insignificant tail) of the Higgs production cross section. In fact such a linear extrapolation of the Higgs cross section in the energy range where there is a significant production will go to zero at some finite  $\sqrt{s}$ , and that value where this linear extrapolation goes to zero we shall call the “effective threshold”. Using the theoretical prediction curves from the article by Tully [20] we obtain for instance using a Higgs mass of  $m_H = 150\text{GeV}$  that the cross section at  $\sqrt{s} = 30 \text{TeV}$  is  $10^{-1} \text{nb}$ , at  $\sqrt{s} = 7 \text{TeV}$ ,  $\sigma = 1.5 \cdot 10^{-2} \text{nb}$  while at  $\sqrt{s} = 14 \text{TeV}$  it is  $4 \cdot 10^{-2} \text{nb}$ . From

this we get by linear extrapolation a zero of the cross section for Higgs mass 150  $GeV$  about 3.4  $GeV$ . Similarly we could for a Higgs mass of 500  $GeV$  find cross section  $2.5 * 10^{-2} nb$  at 30  $TeV$ , and  $10^{-3} nb$  at 7  $TeV$ , while it is  $5 * 10^{-3} nb$  at 14  $TeV$ . This gives us - using to fit linearly only the 14 and the 30  $TeV$  points - an extrapolated zero at  $\sqrt{s} = 10TeV$ .

Theoretically we expect the effective Higgs threshold to scale in  $\sqrt{s}$  proportionally to the Higgs mass - assuming the parton distribution functions to be rather constant - and so it is comforting that the about a factor three in mass between 150  $GeV$  and 500  $GeV$  matches with a ratio close to three for our crudely estimated thresholds 3.4  $TeV$  and 10  $TeV$  for the two masses respectively. For our favourite low mass of 120  $GeV$  - also the one favored by the indirect measurements and the masses more and more getting excluded higher up - we extrapolate to an effective threshold 2.7  $TeV$ . Thus we arrive at the an estimate for effective Higgs production threshold for Higgses of a small mass say around 120  $GeV$  as is the main left over range of Higgs mass is ca 2.7  $TeV$  in  $\sqrt{s}$ . This would correspond to a fixed target beam energy  $(2.7*10^3)^2/2 GeV = 3.6*10^6 GeV = 3.6*10^{15} eV$ . This is very close indeed to the value  $2*10^{15} eV$  which we extracted from the Gaisser curve above. So indeed the agreement with the by linear extrapolation defined threshold for a “light Higgs” is very close to the “knee” !

## 7 Estimation of the crucial number of Higgses to produce backward casation

In addition to the above mentioned problem of the cosmic ray Higgs production our complex action model also has the problem that the Tevatron at FNAL in Chicago (Batavia) presumably already has produced about say 10000 Higgses. Truly we do not know, if it has, because no Higgs bosons have been convincingly observed so far (i.e. in early 2010) and the mass of the Higgs is also known only through very uncertain indirect measurements. But if as is actually supported through a model supported by the picture connected with the complex action model of the present article [2] [17] the Higgs mass is equal to the lower bound for it in the Standard Model, then there would have been already produced according to the Standard Model several thousands Higgs bosons in the Tevatron. With such a low mass of the order of  $120GeV/c^2$ , however, even several thousands of Higgs produced would not have been seen yet.

If we shall uphold the model that Higgs particle production cause bad luck for the production machine we have therefore to withdraw to the position, that it is only a sufficiently big number of Higgs bosons being produced, that will cause sufficient effect to truly cause some visible change in the chance of the number being produced indeed.

### 7.1 How does the probability for bad luck depend on the number of Higgs bosons produced

A very naive and simple thought in our model gives immediately that as the Higgs boson living a time in its rest frame just on the average equal to the Higgs-life-time the suppression of the amplitude (3) occurs with a factor being

$$(exp(-L_I(Higgs)\tau_{Higgs}))^{\#Higgses} = K^{\#Higgses}. \quad (28)$$

Here  $L_I(Higgs)$  is the contribution in the rest system of the Higgs from the Higgs particle, and  $\tau_{Higgs}$  is the average life time form for the Higgs particle, while  $\#Higgses$  denotes the number of Higgs bosons produced. Then the probability which goes as the numerical square this amplitude will also go with the number of Higgses  $\#Higgses$  in the exponent,  $(K^2)^{\#Higgses}$ .

This simple way of looking at it ignores the effect of the competition between different eras in governing the initial conditions. By the competition with the other eras the dependence of the initial conditions or equivalently the realized solution on what goes on in a given era (our era say) is brought appreciably down. It is, however, expected that inclusion of this era-competition-effect will change the constant  $K$  to be much closer to unity. If we therefore just define a phenomenological constant  $a = -\ln(K^2)|_{after\ era-competition-correction}$  we can crudely estimate the probability change to the usually expected probability distribution to say a card pull due to it being made responsible for the switch on or not of a Higgs-producing machine, such as LHC say.

Let us in fact imagine that we decided to pull a card from a usual card-deck and to let LHC be stopped, if we pull a black card while it gets allowed to run fully, if the card pulled is red. Then if our model of imaginary part in the action were not true, there would of course be 1/2 probability for red and 1/2 for black. If now our model were right, however, the non-normalized probability for the red card would be suppressed by a factor  $\exp(-a\#Higgses)$  relative to what it were without the effect of our imaginary part of the action. After normalization we would then get

$$probability(red) = \frac{1/2}{1/2 + 1/2 * \exp(-a\#Higgses)} = \frac{1}{1 + \exp(a\#Higgses)} \quad (29)$$

$$probability(black) = \frac{1/2 * \exp(-a\#Higgses)}{1/2 + 1/2 * \exp(-a\#Higgses)} = \frac{1}{\exp(a\#Higgses) + 1} \quad (30)$$

$$(31)$$

It is from these expressions clearly seen, that one *only gets a significant effect of the imaginary part of the action provided the product  $a\#Higgses$  is of order unity or bigger*. Thus the “phenomenological parameter”  $1/a$  becomes approximately the number of Higgses needed to produce in order to give any significant effect via our model. It is easy to see, that with usual or start probabilities  $P_s(red)$  and  $P_s(black)$  not equal the effect gets less easy to observe. In fact

$$probability(red) = \frac{P_s(red)}{P_s(red) + P_s(black) * \exp(-a\#Higgses)} \quad (32)$$

$$probability(black) = \frac{P_s(black) * \exp(-a\#Higgses)}{P_s(red) + P_s(black) * \exp(-a\#Higgses)} \quad (33)$$

$$(34)$$

is calculated by correcting by the suppression factor and normalizing again to the total probability being unity.

## 7.2 Estimation of the “critical” amount of Higgses $1/a$ needed to cause any backward causation

From the well-running of the Tevatron so far (2010) we can conclude that the parameter  $1/a$  should not be terrible much smaller than the about 10000 which we may take as the order of magnitude for the number of Higgses having been produced by this Tevatron already. It can though be somewhat smaller since it is possibly difficult by adjusting the initial conditions to get such a machine prevented from getting built or to come to run.

Most important for saying something about our parametrization  $1/a$  of our effect is to see what we deduce about it by believing that the failure of SSC were indeed due to our effect. This must mean that indeed  $a\#Higgses$  were at least of order unity, but presumably preferably bigger than unity, where  $\#Higgses$  is taken to be *the number of Higgses that would have been produced in this SSC-accelerator*. According to one plan there is projected a development through 12 years of running (it is of course very difficult to know even for how long a successful SSC-accelerator would have been allowed to work in the hypothetical case, that it were not killed before working at all, but let us here for the estimation take these 12 years as a good estimate.). It should then have had luminosities starting at the first 0.5 year as  $10^{31}cm^{-2}s^{-1}$ , becoming at year 1  $10^{32}cm^{-2}s^{-1}$ , at year 2 a luminosity  $10^{33}cm^{-2}s^{-1}$ , at year 5 luminosity  $2.8 * 10^{33}cm^{-2}s^{-1}$ , reaching at year 10 the luminosity  $8 * 10^{33}cm^{-2}s^{-1}$ , ending with in the 12th year  $10^{34}cm^{-2}s^{-1}$ . Say that it from this would work in about the last 5 years with a little less than the luminosity  $10^{34}cm^{-2}s^{-1}$ ; it would say with a high proportion of time being working indeed have produced an integrated luminosity of the order a bit less than  $5 * 3 * 10^7s * 10^{34}cm^{-2}s^{-1} = 1.5 * 10^{42}cm^{-2}$ . Let us say  $10^{42}cm^{-2} = 10^{18}barn^{-1} = 10^3fb^{-1}$ .

Correspondingly one has for LHC thought of an integrated luminosity up to 2025 of  $5028fb^{-1}$ , only deviating by a factor 5 from the expectation for SSC, LHC having w.r.t. integrated luminosity only a bit (a factor 5) bigger expectation than SSC.

At LHC at full energy  $7TeV + 7TeV = 14TeV$  and Higgs mass 120GeV a cross section of the order of  $30pb$  is expected for Higgs production. Thus at LHC if mainly running full energy we get *produced* - but

certainly not all observed -  $5 * 10^3 fb^{-1} * 30pb = 1.5 * 10^7$  Higgs particles. At SSC the production would be somewhat bigger because of a higher cross section at the higher top energy  $20TeV + 20TeV = 40TeV$ . Even a factor 9 bigger crosssection would only lead to similar order of magnitude of the total number of Higgses produced as in LHC, because of the higher luminosity of LHC, say a factor two more Higgses in all than at LHC.

If indeed LHC should ever come to produce more Higgses than SSC would have done - which though does not sound so easy according to the just given estimates - then the best evidence for our model, the failure of SSC would be lost and our model would, if not formally, then in praxis be falsified.

### 7.3 An estimate of the parameter $1/a$ for the crucial number of Higgses

However, we think we may get a true estimate of the order of magnitude for the significant number of Higgses  $1/a$  by making the assumption that it were not just accidental that at the moment, March 2010, LHC is running at  $3.5TeV + 3.5TeV = 7TeV$  rather than the schedule for full energy per particle  $7TeV + 7TeV = 14TeV$ , because of the physicists having been scared by troubles caused by the “God” in our model. If we in fact assume that there were organized - by our model initial conditions - some troubles connected with the incident more than one year ago, when there were the explosion in the tunnel causing, that for safety the LHC in this moment has to run at the half originally planned energy rather than at this full energy  $14TeV$  in center of mass, then it would mean that the “God” so to speak would *care for the Higgses potentially being produced in the supposedly 18 month periode concerned, if it had ran with the high energy per particle*. Actually we should more precisely say that this “God” would have to care even for the difference in numbers of Higgses produced at  $7TeV + 7TeV = 14TeV$  and the number produced at only  $3.5TeV + 3.5TeV = 7TeV$ . But that does not matter so much order of magnitudewise, because the number of Higgses at  $3.5TeV + 3.5TeV = 7TeV$  will be at least a factor 2 smaller than at the full energy, and thus the difference in number of Higgses will be order of magnitude of what is produced at the full energy of  $7TeV + 7TeV = 14TeV$ . That is to say order of magnitudewise we may estimate also the difference to represent about one or one and a half year of beginning Higgs production at full energy having the  $30pb$  as typical crosssection.

According to some old expectations one should have in LHC  $6fb^{-1}$  in 2009. Now let us interpret it to mean first running year and twice as much second year, which would integrate up to integrated luminosity after two first years of  $18fb^{-1}$ . It is presumably crudely o.k. then to think of  $10fb^{-1}$  as the integrated luminosity at the end of the presently going 18 month periode of running in 2010 to 2011.

The estimated number of would have been with full energy production in these first 18 month would thus be  $30pb * 10fb^{-1} = 3 * 10^5$  Higgses. We therefore would say that under this assumption of the scaring of the physicists to only work with half energy at the moment means that crucial number of Higgses  $1/a$  should be of the order of this number  $3 * 10^5$ .

If this

$$1/a \approx 3 * 10^5 \quad (35)$$

is indeed true then the SSC with its say  $3 * 10^6$  Higgses, it is 10 times as many, would almost certainly have to get stopped somehow if it were at all possible. It would namely have a suppression factor of the order

$$“SSCsuppresion” \approx exp(-a * 3 * 10^6) = exp(-10). \quad (36)$$

It should be stressed that this last case of “God” scaring the energy per particle down to the half value gives roughly the order of magnitude for the  $1/a$  parameter, because we truly have two number of Higgses being tested off - the high number not being allowed, and the one of the half energy being allowed, at least if LHC truly comes to run for of the order of the 18 months planned - and so it gives both upper and lower limit.

We thus really have at least this very weak argument in favour of  $1/a$  truly being of the order of 300000 Higgses.

So if some day LHC reaches to have produced appreciably more than these 300000 Higgses, then, although we could still screw up a bit our  $1/a$  to accomodate such a for our model bad happening, we would then loose the evidence we could now say we see for our model by the scaring down to half energy. So if LHC comes to produce more than these 300000 Higgses then we would loose this case of evidence and it would be so bad for our model, that we should essentially consider it a falsification of our model.

This falsification the just suggested way would occur about the 18 months after the restart after the updating to  $\sqrt{s} = 14TeV$  after the shut down after the present 18 months of running at the “low”  $\sqrt{s} = 7TeV$ . AT that time we can write the paper about our model having been falsified. (I have been suggested this idea of having a falsification by Boerge Svane Nielsen)

## 8 Conclusion

We have reviewed a model by Ninomiya and myself based on the assumption of the fundamental theory being given by the Feynmann-Wentzel-Dirac path way integral in an interpretation involving the time at all times including both past and future; *But most importantly we take the action to be complex!* In a suggestive approximation the model of ours, which turns out to be a model also for the initial conditions, suggests that the (true) solution of the classical equations of motion, through which we live, should be selected by the requirement of minimizing the imaginary part of the action  $S_I[history]$ , so that the latter is the smallest achievable for just this true history of the universe. This approximation may be described by an analogy to a skier with frictionless skies which after severe computer simulation calculations is being started with just the right speed and direction etc. so as to come through the according to the calculation absolutely most beautiful (when integrated up over time) tour. The integrated amount of beauty is in the analogy what corresponds to the imaginary part of the action  $S_I(history)$ . When the tour is constructed to completely optimize/maximize the integrated (amount of) beauty it is the tour analogous to the realized history of the universe (with its analogously minimized  $S_I(history)$ ). We should then find, if our model is true, that the likely features of such an optimized tour on ski can be very similar in an abstract way to what, we see our history of the Universe to be phenomenologically: If there were some place in the landscape that were so beautiful that any optimization hardly could avoid making the tour pass that spot, then the optimized tour would indeed pass that spot; but of course most likely the very most beautiful place would lie on a very steep hill side and it would not be possible to remain there for long with frictionless skies. This most beautiful place should be analogous to some time around the “big bang time”. If this biggest beauty region had so great beauty that it would dominate almost all the rest, we could get in the analogy that the big bang time would have a rather definite state, but that what goes on in other eras will then essentially be a consequence of what were to be organized in this crucial era around big bang, say to have on the to be realized history some special inflaton-field over an optimized long time. This picture favours a sort of bouncing-universe picture with the most important era “Big Bang time” - which does presumably not have a genuine Big Bang but only that the Universe were very small, but not necessarily zero, size - determines to a very large extend what goes on both before and after this era. We should then have in mind that, had we lived in the time before the “Big Bang” era, we would presumably have swichted our notation under a timereversal symmetry and changed the notation from the story, that we live in a world preorganized to reach a special Big Bang situation with an extremely negative  $L_I$  and that we see order comming up (meaning entropy falling). It would have looked that things were getting prearranged so as to make this great event of the inflation like periode be possible with the extremely negative  $L_I$ . But we would easily have timereversed the notation and in stead told the usual story that the inflation with the specially low (presumably very negative)  $L_i$  would be called to be in the past rather than in the future. In this way we could always interpret what happens by saying that on our side of the big bang era entropy grows and universe expands.

It has earlier been argued that the very likely the most important term in the imaginary part of the lagrangian - by a factor  $10^{34}$  we suggest - is the one comming from the imaginary part of the coefficient in the Higgs mass term, i.e. the term proportional to the Higgs field square. It has been remarked that once we identify this term as dominant there is no more so many parameters effectively in the imaginary part as in the real part, because now we can ignore all the many small terms in the imaginary part  $S_I$  and only care the one term proportional to the Higgs field square. This fact gives us better chance for getting predictions of a less general character. We namely know the  $S_I$  effectively under Standard Model conditions up to an over all coefficient.

For instance we can under the assumption of a limit of many parameters argue that there should be a minimum of  $S_I$  as a function of how the baryons are distributed (averaged over time) between protons and neutrons. The argument that it should indeed be so may not be quite watertight, but it could very likely happen that the direct effect of the number of baryons being there as protons versus those that

are neutrons could become a significant term in the imaginary part of the action  $S_I$ . This would have caused there to be either almost no protons or almost no neutrons. To avoid such an incorrect scenario we reached the necessity of having a certain relation between the light quark masses and the electron mass. This relation (20) may also be written in the form

$$\sqrt{m_d^2 - m_u^2} = \sqrt{E_q * m_e} / \sqrt{\ln''}. \quad (37)$$

where we have used the notation  $E_q \approx m_{const}$  to stress that it is really the energy of the quark  $E_q$  in the frame of the nucleon that goes into our formula to give the  $\gamma$  for the quark which is the important thing. We used the energy of the valence quark being 1/6 of proton mass 1GeV and took 165 MeV, which then gives using for the order unity quantity " $\ln'' \approx 2.05$ " that we predict

$$\sqrt{m_d^2 - m_u^2} \text{ 'predicted to' } 9.17/1.43 \text{ MeV} = 6.41 \text{ MeV} \quad (38)$$

to be compared to

$$\sqrt{m_d^2 - m_u^2} = \sqrt{3.5^2 - 1.5^2} \text{ MeV to } \sqrt{6.0^2 - 3.3^2} \text{ MeV} = 3.16 \text{ MeV to } 5.01 \text{ MeV}. \quad (39)$$

We stressed that taking this relation as a success can give a rather strong support for our model with imaginary part also for the action.. It would namely be very difficult for any competing theory to reproduce this relation, because it involves the QCD-scale, and it is really hard to see how that could be connected to the quark and electron masses in such a way as our relation (20,37) states. So our relation should be considered a support for our model of imaginary action with its prearrangements.

We also discussed the important problem with the cosmic rays, that should not hit the earth or other astronomical objects, if really Higgs production should be prevented. Of course it might be so difficult to switch off fully the high energy cosmic ray, so that a total cut off of the high energy spectrum would not pay in the attempt to minimize  $S_I$ . Very interestingly in this connection there is, however, as it has long been known at about the energy of the cosmic ray particle  $10^{15} \text{ eV}$ , *which happens to be very close to the effective threshold for producing many Higgs particles*, a rather sharp fall off, more rapidly than at lower energies. This is what is known as the "knee" in the cosmic ray spectrum. As this spectrum has been studied well over several orders of magnitude, even the only order of magnitude coincidence of the energy scale at which Higgses begin to be produced copiously and the scale of the "knee" becomes somewhat remarkable! Did our imaginary action model indeed arrange that the main source of cosmic ray from supernovae in the galaxy just stops, where the Higgses begin to be produced copiously? The effect of this "knee" in suppressing the production of many Higgs bosons in hits on astronomical objects is further enhanced by the result [22].

## 8.1 Further study

Some of the fine tunings being possibly explained by some anthropic principle derivation, might likely be instead explained by the  $S_I$ -minimization. For instance the existence of stable Helium-2[23][24] nucleus could potentially increase the rate of star development appreciably by making the weak interaction proton-proton process starting the nuclear formation process in the stars be replaced by the electromagnetic formation of Helium-2. If there were such an effect the fact that the Helium-2 nucleus is just very barely unstable and thus useless in the star development could be considered a result of our model. In fact our minimization of  $S_I$  would be seeking to delay the formation of black holes with lot of high energy physics going on such as e.g. Higgs production. Now, however, Bradford[25] has pointed out that in contrafactual world with a stable Helium-2 stars with similar life times as they have the real world are not excluded. So the argument is not necessarily so simple; but in our model whenever something dramatically would happen by varying a coupling there is a high chance that it would cause also dramatic effects on  $S_I$  and at the end drive the history of the universe and probably even the couplings to adjust into neighborhood of the dramatic shift.



## 9 Acknowledgement

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